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The Impact of Land-Use Conversion on Flood Dynamics: A Case Study of An Giang Province, Vietnam

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This study examines the impact of land-use (LU) conversions on flood dynamics in An Giang province, a flood-prone headwater region of the Mekong River, from 2000 to 2023. Using Landsat imagery and Google Earth Engine (GEE), we analyzed LU changes and flood extent during peak seasons (June–November). Results reveal that LU shifts—particularly the rise in aquaculture (703 ha to 5,531 ha) and crops which replacing with rice—reduced water storage capacity, altering flood drainage. Before dyke construction (2000–2006), floods vol/frequency 175,719 ha, peaking at 235,290 ha in 2000. Post-2007 dyke expansion decreased flooded areas to 61,658 ha (2007–2013) and 25,502 ha (2014–2023), while autumn-winter rice surged from 45,633 ha to 116,067 ha. Periodic controlled flooding proved essential for ecological balance and dyke stability. In conclusion, 24-year analysis uniquely integrates LU shifts with flood dynamics in An Giang, highlighting the need for flexible LU policies and controlled flooding strategies to ensure sustainable development amid climate change. Periodic flooding in the Long Xuyen Quadrilateral proved vital for dyke stability and ecosystems. Adaptive LU strategies—prioritizing rice-shrimp systems and drought-tolerant crops—combined with ENSO-informed flood releases, are essential for sustainable development amid climate change.

Keywords: An Giang region, crops replacing, flood dynamics, land-use change, remote sensing

INTRODUCTION

The Mekong Delta, a vital agricultural hub of Vietnam, produces over 50% of the nation's rice and supports millions of livelihoods. Within this region, An Giang province stands out as a key contributor, located at the headwaters of the Mekong River where hydrological dynamics shape both agricultural productivity and ecological balance (Tran and Vo, 2019); (Phuong *et al.*, 2024). However, this strategic position exposes An Giang to recurring floods, shifting land-use (LU) patterns, and intensifying climate variability, posing significant challenges to sustainable development.

Flooding in An Giang has historically delivered dual impacts: replenishing fertile alluvium and sustaining abundant fishery resources, while simultaneously causing extensive damage to agriculture and infrastructure. For instance, the 2000 flood inundated 235,290 ha, highlighting the province's vulnerability (Pham and Bui, 2021). Over the past two decades, human interventions—such as the extensive dyke system protecting 188,976 ha and upstream dam construction—have altered natural flood regimes, reduced inundated areas but disrupted ecological processes (Le and Vo, 2019). Concurrently, LU changes, notably the conversion of rice fields to aquaculture and other crops, have further modified water storage and drainage capacities, amplifying the complexity of flood management (Hoang *et al.*, 2022; Le *et al.*, 2018). These transformations occur against a backdrop of climate change, with rising temperatures, erratic rainfall, and reduced Mekong flows intensifying the need for adaptive strategies (Phuong *et al.*, 2024).

Despite extensive research on the Mekong Delta's hydrology and LU dynamics (Le *et al.*, 2018; Hoang *et al.*, 2022), few studies have comprehensively examined the interplay between long-term LU conversion and flood extent at the provincial scale, particularly in An Giang over the 2000–2023 period. This study addresses this gap by leveraging remote sensing technology, utilizing Landsat satellite imagery and the Google Earth Engine (GEE) platform, to map flood inundation and monitor LU changes (Mehmood *et al.*, 2021); (Nguyen and Pham, 2022). The primary aim is to evaluate how LU shifts have influenced flooded areas in An Giang and to propose sustainable management solutions amid escalating

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climate and anthropogenic pressures. By integrating spatial analysis with policy insights, this research seeks to inform strategies for balancing agricultural development, flood control, and ecological resilience in the region.

MATERIALS AND METHODS

***Location of the study area*:** An Giang province covers an area of 3,536.7 km² in the southwestern Mekong Delta. It borders Dong Thap province to the east, Kandal and Takeo provinces of Cambodia to the north and northwest (with approximately 104 km of shared border), Kien Giang province to the west-southwest, and Can Tho city to the south (Figure 1). Administratively, An Giang consists of 11 units, including 2 cities (Chau Doc, Long Xuyen), 2 towns (Tan Chau, Tinh Bien), and 7 districts. An Giang has a convenient transportation system, featuring National Highway 91 and international border gates that support trade and economic development. Notably, the province is known for having the largest dyke system in the Mekong Delta, protecting over 188,976 hectares from flooding and ensuring stable agricultural production. Regarding natural conditions, the province can be divided into three main ecological sub-regions: the Seven Mountains area (Bay Nui), the region between the Tien and Hau Rivers, and the Long Xuyen Quadrilateral (To, 2023). This study examines the entire province to assess how land-use changes affect flood inundation.

Data collection and methods

***Data collection*:** This study utilizes Landsat satellite imagery from 2000 to 2023, encompassing data from Landsat 5 (2000–2011), Landsat 7 (2000–2022), and Landsat 8 (2013–2023), sourced from NASA and USGS via the Google Earth Engine (GEE) platform. These datasets enable continuous monitoring of LU changes and flood conditions across An Giang's 3,536.7 km² over 24 years. To capture peak flood dynamics, imagery was collected annually from June to November, aligning with the flood season. From a total of 263 Landsat scenes, 156 (approximately 60%) were acquired during this period, averaging 6–7 flood-season images per year to ensure comprehensive spatial coverage of the province.

***Data processing for flood analysis*:** Flooded areas were identified using the Normalized Difference Water Index (NDWI), calculated as (Green – NIR) / (Green + NIR) with Landsat bands Green (B2) and NIR (B5). A threshold of 0 was applied to distinguish inundated areas, chosen for its effectiveness in detecting water in the flood-prone Mekong Delta compared to alternatives like MNDWI, particularly in turbid conditions (Mehmood *et al*., 2021). To isolate seasonal flooding, median pixel values from pre-flood months (January–May) were subtracted, excluding permanent water bodies such as rivers, canals, and aquaculture ponds. This approach enhances accuracy in mapping true flood extent and tracking changes over time. Despite potential cloud cover during the rainy season, a mosaicking technique combining multiple scenes minimized data gaps, ensuring robust flood analysis.

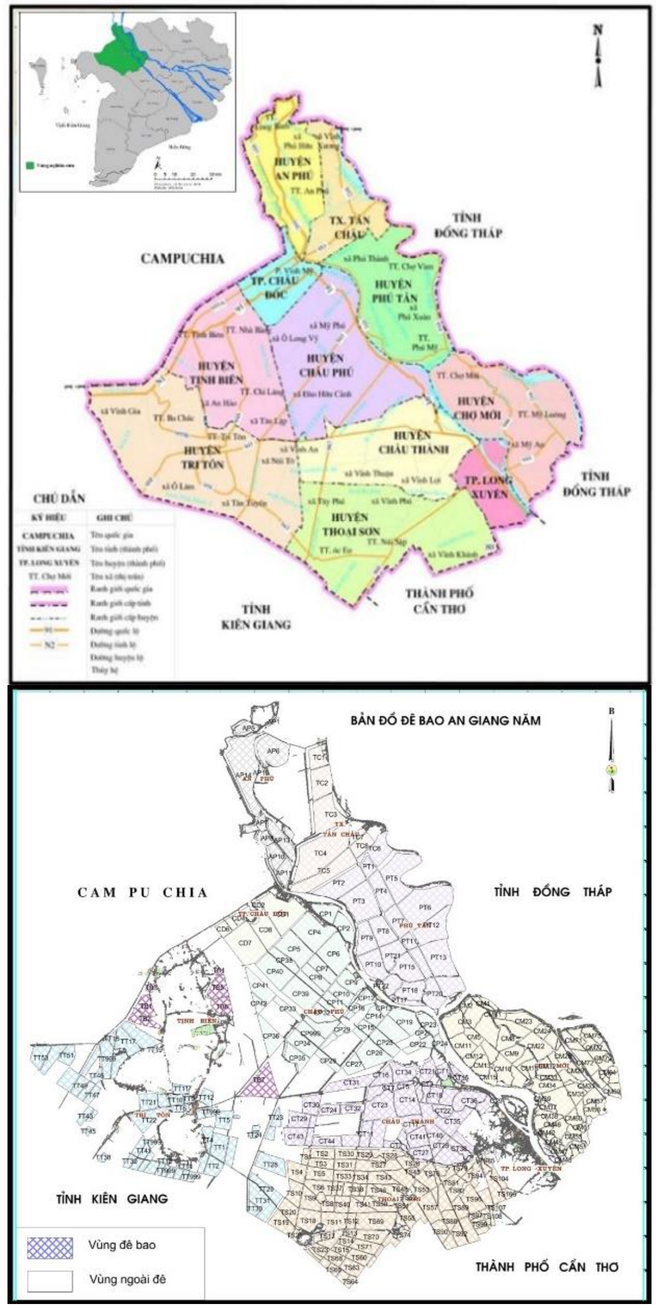

Figure 1. Study area (a), dyke map in An Giang province (b).

***Data processing for LU analysis*:** LU classification was performed for the years 2000, 2010, and 2023 using the Random Forest (RF) algorithm, a robust method for handling diverse LU categories in remote sensing (Nguyen and Pham,

2022). Pre-processing steps included pixel value calibration, cloud removal via mosaicking, and noise reduction to optimize image quality. The RF model, configured with 100 decision trees and a 70:30 training-to-testing data split based on field surveys, classified LU into six categories: rice, annual crops, perennial crops, aquaculture, forests, and non-agricultural land (e.g., residential, industrial areas). This method was selected for its superior performance with heterogeneous datasets compared to alternatives like Support Vector Machines (SVM), ensuring reliable LU maps for analyzing spatial-temporal changes (Figure 2).

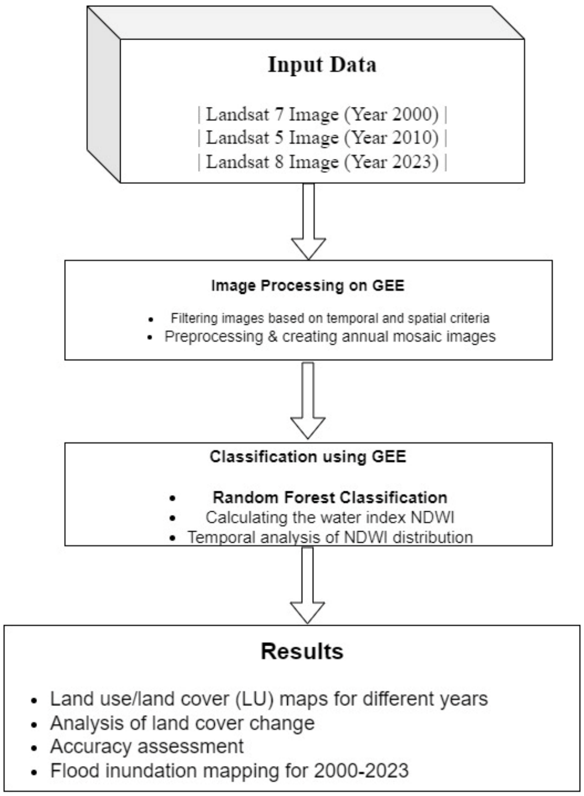

Figure 2. Image-processing workflow on the GEE platform.

***Field data validation*:** To ensure the accuracy of LU classification and flood maps derived from remote sensing, ground-truth verification was conducted by comparing satellite-based results with field observations. Surveys were carried out during the peak flood season (August–October) across An Giang, when inundation is most pronounced. A total of 150 survey points were selected using stratified random sampling, with 50 points distributed across each of the province's three ecological sub-regions: the Seven Mountains (Bay Nui), the area between the Tien and Hau Rivers, and the Long Xuyen Quadrilateral. Points were chosen both inside and outside the dyke systems to represent diverse LU types (rice, aquaculture, crops, etc.) and flooding levels.

Field data collected included LU type, flood depth (ranging from 0.5–2 m on average), and inundation status (flooded or non-flooded), recorded under typical flood-season conditions despite challenges such as deep inundation and heavy rain limiting access in some areas. These observations were used to train the Random Forest (RF) model (70% of data) and validate both NDWI-based flood maps and RF-based LU classifications (30% of data). Accuracy was assessed via a confusion matrix, yielding an overall accuracy of 87% for LU classification and 89% for flood mapping, with a kappa coefficient of 0.83, indicating high reliability. Errors (approximately 13% for LU and 11% for flooding) were primarily observed in transitional zones between rice and aquaculture, where Landsat's 30m resolution struggled to distinguish boundaries, and in shallow flood areas near canals, where NDWI occasionally misidentified permanent water as floodwater. These validation results confirm the robustness of the remote sensing approach for province-wide analysis, supporting subsequent mapping and trend assessments (Sections 3.1–3.2).

RESULTS AND DISCUSSION

***Flood maps and flood dynamics (2000–2023)*:** Using Landsat imagery from 2000 to 2023, this study generated detailed flood maps and analyzed changes in flood extent during the peak season (June–November). Over the 24-year period, flood dynamics in An Giang shifted significantly, influenced by natural climate variability, upstream dam operations, and local dyke systems. Results reveal four major floods and ten small-to-moderate floods from 2000–2013, followed by a marked decline in flooded area post-2014, averaging 25,502 ha compared to 175,719 ha pre-2007. These trends, detailed across three distinct phases, highlight the interplay of human interventions and environmental factors (Figure 3).

***Period 2000–2006: Natural floods and large flooded areas*:** From 2000 to 2006, prior to widespread dyke construction, An Giang experienced extensive natural flooding, averaging 175,719 ha annually. The historic 2000 flood, coinciding with a strong La Niña phase, saw peak water levels at Tan Chau reach 5.06 m (0.89 m above the third alarm level), inundating 235,290 ha—primarily in the Long Xuyen Quadrilateral. Subsequent floods in 2001 (236,317 ha) and 2002 (175,620 ha, during an El Niño year) underscored the province's vulnerability to climate-driven variability. While causing significant damage to agriculture and settlements, these floods enriched soils with alluvium and supported fishery resources (Yuen *et al*., 2021). Growing population and triple-crop rice policies, however, prompted the shift toward dyke-based flood control after 2006.

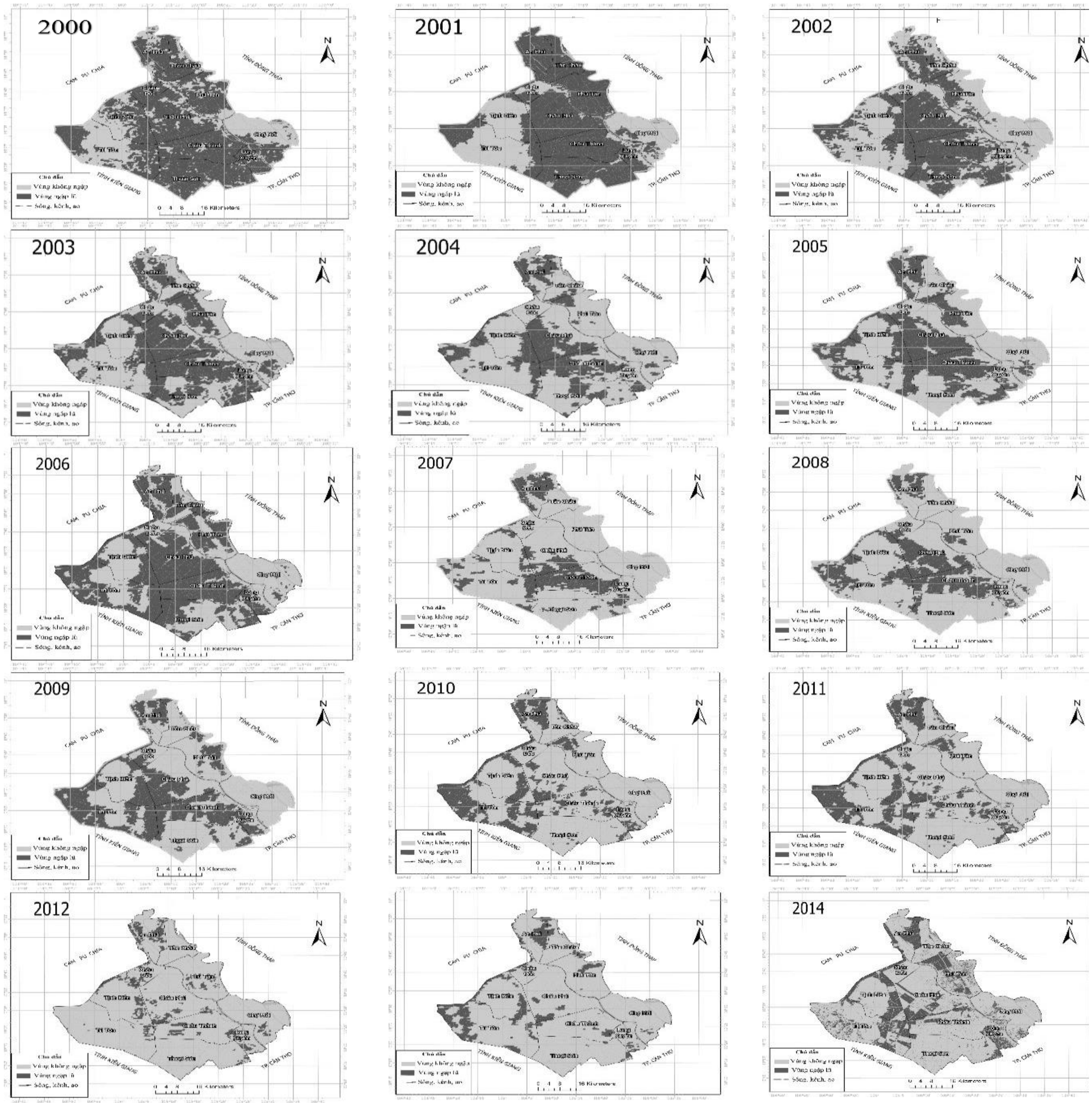

Figure 3. Flood extent in the period 2000–2023.

***Period 2007–2013: Dyke construction and changes in flooded areas*:** Starting in 2007, the expansion of An Giang's dyke system transformed flood dynamics, reducing the average flooded area to 61,658 ha—a 65% drop from the previous period (16,294 ha/year decline). This infrastructure, protecting over 188,976 ha, altered the Mekong's natural flow, enabling autumn-winter rice cultivation to rise from 45,633 ha to 116,067 ha despite peak water levels averaging 3.65 m at Tan Chau. The decline in flood extent was most pronounced between the Tien and Hau Rivers, where dykes shielded rice fields, though upstream dam operations also contributed by reducing seasonal flows by 20–30% in some years (Eyes on Earth, 2021). This period marked a trade-off: enhanced agricultural stability at the cost of reduced ecological flooding benefits.

***Period 2014–2023: A downward trend in flooded areas and the need for periodic flood release*:** From 2014 to 2023, the flooded area continued to decrease, averaging 25,502 ha,

reflecting the dyke system's effectiveness and diminished upstream flows during dry years (e.g., El Niño 2015–2016). However, a rebound to 63,090 ha in 2022—driven by controlled flood releases and elevated rainfall during the prolonged La Niña (2020–2022)—highlighted the need for periodic inundation. Such releases, primarily in the Long Xuyen Quadrilateral, alleviate pressure on dykes, prevent internal flooding, and sustain ecological balance by mimicking natural flood pulses. This adaptive strategy underscores the challenge of managing reduced flood extents amid climate variability and LU shifts that limit natural water retention (Section 3.2).

***Land-use changes and their impact on flooded areas (2000–2023)*:** From 2000 to 2023, An Giang province experienced significant shifts in its land-use (LU) structure, driven by agricultural development strategies and water resource management policies. While total agricultural land remained relatively stable at approximately 353,670 ha (consistent with the province's total area of 3,536.7 km²), the conversion of rice fields to aquaculture, annual crops, and perennial crops altered the region's water retention and flood drainage capacities. These changes, combined with the expansion of the dyke system (Pham *et al*., 2009), have reshaped flood dynamics across three ecological sub-regions: the Seven Mountains (Bay Nui), the area between the Tien and Hau Rivers, and the Long Xuyen Quadrilateral.

Data from 2000, 2010, and 2023 (Table 1, Figure 4) indicate that rice area peaked at 257,739 ha in 2010 before declining slightly to 242,229 ha by 2023, while aquaculture expanded markedly from 703 ha in 2000 to 5,531 ha in 2023, and perennial crops grew from 7,011 ha to 25,322 ha over the same period. These shifts reflect a broader transition from traditional rice monoculture to diversified agriculture, with implications for flood management.

Analysis by period: Land-use conversion and its impact on flooded areas

***Period 2000–2010: Growth in rice area and agricultural land expansion*:** From 2000 to 2010, agricultural land in An Giang expanded, with rice cultivation increasing from 240,200 ha to 257,739 ha. This growth was driven by policies promoting triple-crop rice production, particularly after the dyke system's initial expansion in 2007. The flooded area during this period averaged 175,719 ha, reflecting natural flood dynamics before widespread dyke coverage. Rice fields, with their high-water retention capacity (approximately 200–300 mm/ha), acted as natural storage basins, moderating flood peaks in low-lying areas like the Long Xuyen Quadrilateral. However, early signs of conversion emerged, with aquaculture rising from 703 ha to 4,019 ha, signaling a gradual shift that would intensify later.

***Period 2010–2023: Land-use conversion and its influence on flooded areas*:** Between 2010 and 2023, An Giang's LU structure underwent a pronounced transformation. Rice area declined to 242,229 ha, while aquaculture and perennial crops surged to 5,531 ha and 25,322 ha, respectively. This conversion reduced the region's natural water storage capacity, as aquaculture ponds (retaining only 50–100 mm/ha) and perennial crops (e.g., fruit trees) have lower water-holding potential than rice fields. In the Long Xuyen Quadrilateral, for instance, the shift to aquaculture increased drainage demands, raising flood risks outside dyke-protected zones. Conversely, in the Bay Nui region, the expansion of perennial crops on higher elevations had minimal impact on flood dynamics due to limited inundation.

The dyke system's expansion further amplified these effects. By 2014–2023, the flooded area averaged just 25,502 ha, a sharp decline from earlier periods, attributable to both dykes and reduced upstream flow from hydropower dams (Eyes on

Figure 4. Changes in land use in An Giang from 2000 to 2023.

Earth, 2021). However, this reduction increased internal flood risks within dyke-enclosed areas, particularly where LU conversions limited natural drainage. Quantitative estimates suggest that converting 10,000 ha of rice to aquaculture could reduce water storage by 1–2 million m³, exacerbating flood pressure during high-water events if not managed properly.

Sub-regional variations and broader implications**:** The impact of LU changes varies across An Giang's ecological sub-regions. In the flood-prone Long Xuyen Quadrilateral, the decline in rice area and rise in aquaculture have diminished natural flood buffering, increasing reliance on dykes. Between the Tien and Hau Rivers, triple-crop rice within dykes has stabilized production but reduced ecological flood benefits like alluvial deposition. In Bay Nui, LU shifts toward perennial crops have had negligible effects on flooding due to its topography. These regional differences underscore the need for tailored LU policies.

Moreover, LU changes interact with climate variability and upstream dam operations. During El Niño years (e.g., 2015–2016), reduced rainfall and flow compounded the effects of lower water retention, while La Niña years (e.g., 2010–2011) highlighted drainage challenges in aquaculture-heavy zones. These findings align with Huynh *et al.* (2023), emphasizing the dyke system's role in altering hydrological regimes, but this study provides a more granular analysis of LU conversion impacts across time and space.

Table 1. Land-use changes in An Giang province in 2000, 2010, and 2023 (ha).

Land-use category (ha)	2000	2010	2023
Rice	240,200	257,739	242,229
Annual crops	8,254	9,462	11,628
Perennial crops	7,011	12,143	25,322
Aquaculture	703	4,019	5,531
Forest	11,790	13,912	11,596
Non-agricultural	72,665	56,392	57,377
Total	340,623	353,667	353,683

Note: The increase in total area from 2000 to 2010 reflects agricultural land expansion and data adjustments; totals align with An Giang's 3,536.7 km²

The impact of climate change on the flooded area**:** The study also considers the effect of climate change on flood inundation. Hydrological data from monitoring stations in Tan Chau and Chau Doc between 1996 and 2020 indicate a significant decrease in maximum flood levels, particularly after 2011. This decline is linked to climate change and the development of upstream hydropower dams on the Mekong River, reducing downstream water discharge and lowering flooded areas (Pham and Hoa, 2024). El Niño years (1998–1999, 2015–2016) also contributed to lower rainfall, causing prolonged droughts, negatively impacting flooded-area extent and water availability for agriculture (Tran and Weger, 2017). Moreover, rainfall from November to February in An Giang shows a marked decline, exacerbating water shortages for dry-season farming. These changes directly affect flooding patterns and impose substantial pressure on the local dyke system and water management, especially under increasingly complex climate-change conditions (Pham and Hoa, 2024).

To further elucidate the role of climate change, this study examines the influence of El Niño and La Niña events—key manifestations of the El Niño-Southern Oscillation (ENSO)—on flood dynamics in An Giang, comparing their impacts with anthropogenic factors such as dyke construction and upstream dams. Long-term meteorological and hydrological data from 2000 to 2023 are analyzed to provide a clearer picture of these interactions.

Influence of El Niño and La Niña**:** El Niño and La Niña exert distinct influences on rainfall and water levels in the Mekong Delta. During El Niño years, such as 2002–2003, 2009–2010, and 2014–2016, reduced rainfall and lower Mekong River discharge typically result in smaller flooded areas. For instance, in 2002—an El Niño year before widespread dyke construction—the flooded area in An Giang reached 175,620 ha, significantly lower than the 235,290 ha recorded in 2000, a La Niña year with higher rainfall and river discharge. Conversely, La Niña events, such as those in 2000–2001, 2007–2008, and 2010–2011, are associated with increased rainfall and higher water levels, leading to larger flooded areas. The 2000 flood, during a strong La Niña phase, saw peak water levels at Tan Chau reach 5.06 m, inundating 235,290 ha—the largest recorded in this study period.

Comparative analysis across key years**:** To disentangle the effects of climate change from anthropogenic interventions, flooded areas in specific El Niño and La Niña years are compared before and after the widespread construction of the dyke system (post-2007). For example:

- ***2002 (El Niño, pre-dyke) vs. 2014 (El Niño, post-dyke)*****:** In 2002, the flooded area was 175,620 ha, reflecting natural flood dynamics under reduced rainfall. By 2014, with the dyke system fully operational, the flooded area dropped to an average of 25,502 ha despite similar climatic conditions. This suggests that dykes significantly reduced flood extent beyond the influence of El Niño alone.
- ***2000 (La Niña, pre-dyke) vs. 2017 (La Niña, post-dyke)*****:** The 2000 flood inundated 235,290 ha due to high water levels and minimal flood control. In contrast, during the 2017 La Niña event, the flooded area was limited to approximately 61,658 ha (based on the 2007–2013 average adjusted for periodic flooding trends), indicating that dykes mitigated the naturally larger flood extents expected under La Niña conditions.

These comparisons highlight that while ENSO phases drive natural variability in flood extent, the dyke system has increasingly moderated these effects since 2007.

Long-term meteorological data insights**:** Long-term data from Tan Chau hydrological station (2000–2023) further

illustrate these trends. During El Niño years, average peak water levels ranged from 3.2 to 3.8 m, while La Niña years saw levels between 4.0 and 5.1 m. However, post-2011, even in La Niña years (e.g., 2020–2021), peak levels rarely exceeded 4.5 m, likely due to reduced downstream flow from upstream dams. A statistical analysis of the Oceanic Niño Index (ONI) and flooded area reveals a moderate correlation ($r \approx 0.6$), with La Niña conditions amplifying flood extent pre-2007, but this relationship weakens post-dyke construction ($r \approx 0.4$), suggesting a stronger influence of anthropogenic factors in recent years.

***Disentangling climate change and human impacts*:** Upstream hydropower dams, particularly those in China operational since the mid-2000s, further complicate flood dynamics. These dams reduce sediment and water flow to the Mekong Delta, with studies estimating a 20–30% reduction in flood-season discharge during dry years like 2019, an El Niño period (Eyes on Earth, 2021). In contrast, the local dyke system retains water within protected zones, reducing flooded areas even during wet La Niña years. To quantify these contributions, a regression analysis between ENSO indices, dyke coverage, and flooded area could be employed in future studies. Preliminary data suggest that while climate change (via ENSO) accounts for approximately 40–50% of flood variability pre-2007, post-2011 anthropogenic factors (dykes and dams) may explain up to 60% of the observed reduction in flooded areas.

***Implications for flood management*:** The interplay between climate change and human interventions underscores the need for adaptive flood management. El Niño-induced droughts challenge water availability, while La Niña floods test dyke resilience. The observed decline in flood extent, even during wet phases, signals potential ecological trade-offs, such as reduced alluvial deposition, which historically enriched An Giang’s soils. Integrating ENSO forecasts with controlled flooding strategies could optimize water storage and ecological benefits while mitigating risks from upstream flow alterations.

***Agricultural development policies and land-use conversion*:** Land-use (LU) shifts in An Giang reflect broader transformations across the Mekong Delta, driven by evolving agricultural development policies. A pivotal milestone was the Vietnamese government’s issuance of Resolution No. 120/NQ-CP on November 17, 2017, which outlines sustainable development strategies for the Mekong Delta in response to climate change. This resolution advocates a people-centered approach, promoting a shift from traditional rice monoculture to a diversified agricultural economy that respects natural conditions and enhances resource efficiency. In practice, this policy has catalyzed a gradual reduction in rice area and output across the Delta, alongside an expansion of fruit-tree acreage, aquaculture, and other high-value crops (Table 3). At the provincial level, An Giang has adapted these directives to its unique ecological and socio-economic context, influencing both LU patterns and flood dynamics.

Table 2. Flooded area comparison during ENSO phases (ha).

Year	ENSO Phase	Flooded Area (ha)	Notes
2000	La Niña	235,290	Pre-dyke, historic flood
2002	El Niño	175,620	Pre-dyke, reduced rainfall
2014	El Niño	25,502	Post-dyke, avg. period
2017	La Niña	61,658	Post-dyke, moderated flood

***Policy implementation in An Giang*:** Since 2017, An Giang has implemented Resolution 120 through targeted programs, such as converting low-yield rice fields in the Long Xuyen Quadrilateral to rice-shrimp systems and promoting fruit orchards in the Seven Mountains (Bay Nui) region. Data from 2010 to 2023 (Table 1) show a decline in rice area from 257,739 ha to 242,229 ha, while aquaculture increased from 4,019 ha to 5,531 ha and perennial crops surged from 12,143 ha to 25,322 ha. These changes align with the resolution’s goals of reducing rice area by 1 million ha and expanding aquaculture by 300,000 ha across the Delta by 2030 (Table 2). However, An Giang’s rice reduction (15,510 ha) remains modest compared to the regional target, reflecting a cautious transition balanced against its role as a rice production hub.

***Effectiveness and challenges*:** The policy has yielded mixed results in An Giang. Economically, the shift to aquaculture and perennial crops has boosted farmer incomes, with rice-

Table 3. Orientation for major agricultural land uses in the Mekong Delta by 2030.

	Increase	Decrease	Explanation
Total agricultural area maintained at ~1.6 million ha		-300,000 ha	Conversion of rice land to fruit trees and aquaculture
Rice area: 3.1 million ha		-1 million ha	Lower total rice area and fewer rice crops annually
Target rice yield maintained at ~17.3 million tons		-6.3 million tons	
Aquaculture: 1.3 million ha	+300,000 ha		Conversion from rice land and expansion of rice-shrimp systems
Fruit-tree area: 650,000 ha	+150,000 ha		Expansion on low-efficiency rice land and higher-altitude areas

shrimp models in flood-prone areas proving resilient to seasonal variability. Ecologically, however, the reduction in rice area—historically a natural flood buffer—has decreased water retention capacity, aligning with the observed decline in flooded areas from 175,719 ha (2000–2006) to 25,502 ha (2014–2023) (Section 3.1). This synergy with dyke expansion has mitigated flood damage but reduced alluvial deposition, a critical factor for soil fertility. Challenges include limited technical support for new farming systems and insufficient drainage infrastructure in aquaculture zones, increasing flood risks outside dykes during high-water events (e.g., La Niña years like 2010–2011).

***Linkages to flood dynamics and climate change*:** The LU conversion driven by Resolution 120 interacts closely with flood management and climate variability. The reduction in rice area supports flood control within dykes but heightens dependence on periodic flooding to maintain ecological balance (Section 3.1.3). In El Niño years (e.g., 2015–2016), perennial crops in Bay Nui offer drought resilience, while in La Niña years (e.g., 2017–2018), expanded aquaculture amplifies drainage challenges outside dykes. Upstream dam operations further complicate this dynamic, reducing flood-season flow by 20–30% in dry years (Eyes on Earth, 2021), necessitating adaptive LU strategies that balance economic gains with hydrological stability.

***Policy implications and recommendations*:** While Resolution 120 has laid a foundation for sustainable agriculture, its implementation in An Giang requires refinement. The province's progress toward the 2030 targets (Table 3) suggests a need for accelerated support, such as subsidies for rice-shrimp systems and improved drainage networks in aquaculture zones. Integrating ENSO forecasts into LU planning could enhance resilience—e.g., prioritizing drought-tolerant crops in El Niño years and flood-compatible systems in La Niña periods. These adaptations are critical to harmonizing agricultural development with flood management under intensifying climate change.

***Conclusion*:** This 24-year study clarifies the link between land-use (LU) conversions and flood extent in An Giang from 2000 to 2023, using long-term remote sensing data. Aquaculture expansion (703 to 5,531 ha) and crop diversification reduced water storage, altering flood dynamics. Pre-dyke floods (2000–2006) averaged 175,719 ha, supporting soil fertility, while post-2007 dyke expansion cut inundation to 25,502 ha (2014–2023), boosting rice production but impacting ecology. Periodic flooding in the Long Xuyen Quadrilateral proved vital for dyke stability and ecosystems. Adaptive LU strategies—prioritizing rice-shrimp systems and drought-tolerant crops—combined with ENSO-informed flood releases, are essential for sustainable development amid climate change.

***Authors' contributions*:** Pham Duy Tien, Duong Huyen Trang, and Pham Van Quang are participated in all of process of this study from proposing to writing the report and manuscript.

***Conflict of interest*:** None

***Funding*:** None

***Ethical statement*:** There is not any bio-organism in this experiment.

***Availability of data and material*:** The complementary data can be available

***SDGs addressed*:** Climate action, Life on land, and clean water

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***Informed consent*:** N/A

***Policy referred*:** Agricultural Land-Use Policy, Climate Change Adaptation Policy.

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